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NASA TECH BRIEF

Highly Sensitive Solids Mass Spectrometer Uses Inert-Gas Ion Source

The problem:

To design a highly sensitive (parts-per-billion range) mass spectrometer that will provide a recorded analysis, including isotopic composition, of solid material surfaces and bulk. The test samples should not require special cleaning before analysis or show any change in chemical composition such as produced by a spark discharge in the conventional solids mass spectrometer.

The solution:

A new mass spectrometer employing a beam of high-energy inert-gas ions to bombard the surface atoms of a sample and convert a significant percentage of them into an ionized vapor. A portion of this vapor is focused into the mass spectrum analyzer and the ionic constituents are separated according to their mass-to-charge ratio.

How it's done:

The mass spectrometer consists of a spectroscopically pure primary source of inert-gas (e.g., argon, xenon) ions, a target chamber, a mass analyzer, and an electronic ion detector. The target chamber is evacuated with a six-inch mercury diffusion pump; a two-inch mercury diffusion pump evacuates the primary ion source. The analyzer section is evacuated by a combination zeolite sorption trap and titanium sputter-ion pump. The system is ready for operation approximately 10 minutes after the sample is placed in the target chamber, which is evacuated below 10^{-6} Torr. A low-voltage arc is then initiated in the ion source, which is maintained at 10^{-2} Torr from the inert-gas reservoir. This arc is constricted by an axial magnetic field, so that a very dense plasma is created along the axis near the anode. Through a pinhole in the anode, an intense beam of inert-gas ions is extracted and accelerated by a conically shaped electrode, producing a beam of small cross-sectional area. The beam bombards the target (sample) at an oblique angle causing a high rate of sputtering, without chemical reaction, and the target remains uncontaminated.

The secondary ions of surface material produced in this manner are focused electrostatically into a double-focusing mass spectrometer where they are separated in a magnetic sector according to their momentum-to-charge ratio. These ions are subsequently sorted according to their energy by an electrostatic analyzer. The intensity of the ion current corresponding to a given mass peak is measured electronically. A spectrum is obtained when the potential through which the surface ions are accelerated is changed or when the magnitude of the magnetic field at constant ion accelerating potential is changed. A permanent record of this spectrum is obtained by synchronizing the horizontal sweep of an X-Y recorder with the parameter varied and making the vertical deflection proportional to the ion current.

Notes:

1. This instrument directly records trace constituents of conducting and nonconducting materials in parts per million. For smaller concentrations, it is necessary to use a digital memory oscilloscope. This memory device extends the sensitivity of the spectrometer by at least two orders of magnitude.
2. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Electronics Research Center
   575 Technology Square
   Cambridge, Massachusetts, 02139
   Reference: B66-10114

(continued overleaf)

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C., 20546.

Source: GCA Corporation
under contract to
Electronics Research Center
(ERC-11)